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COMPLETE SPECIFICATION

Improvements in or relating to Apparatus for and Method of Comminuting a Permeable Material

We, INSTITUTE OF GAS TECHNOLOGY, a corporation organized under the laws of the State of Illinois, United States of America, of 3300 Federal Street, Chicago, State of Illinois, United States of America, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to an improved method and means for comminuting permeable substances by flash pulverization and is directed more particularly to a method of and apparatus for comminuting such substances so that the resultant product is delivered in a continuous flow to a receiving chamber under circumstances whereby the particle surfaces are in an active condition to enhance the speed and completeness of further reactions. If desired, a plurality of systems embodying the present invention may be used either in series or in parallel, the series arrangement giving increased pulverization and the parallel arrangement giving increased output of the pulverized product.

While, for purposes of description, the invention herein is described in conjunction with comminuted coal, it will be understood that the method and apparatus described herein may be utilized for the comminution of a wide variety of materials for a wide variety of purposes.

The present invention provides an apparatus for comminuting a permeable material, including means for entraining in and permeating with a fluid stream, a mass of flowable particles of such material, and means for subjecting the stream and the entrained particles to a high ratio of expansion during flow therethrough the apparatus to explode the particles and to comminute the same.

One of the important objects of the present invention is to provide an improved method whereby the desired comminution may take place as a continuous process with extreme rapidity so that the reduction in particle size is an instantaneous operation on the order of about one twelve thousandth of a second as distinguished from those methods relying upon progressive attrition as the disintegrating factor and to provide an improved apparatus for practicing the method of the invention.

Still another object of the present invention is to pulverize a permeable material such as coal and the like by first entraining it in a stream of fluid, air, steam or other gas and then subjecting the entrained particles to instantaneous differential pressure conditions while they travel at an exceedingly high speed.

It is another object of the present invention to attain the above end in an improved simple and cheap manner.

In considering the pulverization or comminution of particles, it has been found that certain materials when pulverized are provided with highly active particle surfaces and that if the transition from a larger particle size to a smaller particle size can be accomplished with sufficient rapidity this active condition of the surfaces may be maintained to augment the speed and completeness of further reactions to which the particles are subjected after comminution. Thus it is found that by the treatment of the particles while traveling at a high velocity and by the resulting rapidity of the comminution thereof, the transition from larger particle size to smaller particle size is accomplished in such a manner that the smaller particles are available for further reaction while the active surfaces thereof are still unaffected detrimentally by their environment.

It is still another important object of the present invention to provide a method of and means for comminuting a permeable material whereby the comminution may be accomplished with great rapidity while the particles are traveling at a high velocity yet without requiring the build up of high pressure conditions in the entraining gas. Thus, while relatively high initial pressure may be

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used, if desired, a relatively cheap low pressure gas supply may be utilized and yet at the same time may obtain the necessary high velocities and the desired rapidity of transition from large particles to small particles.

It is another object of the invention to provide an improved method of and apparatus for comminuting a permeable material such as coal or the like by entraining the same in a relatively low pressure gas or vapour stream and subjecting the entrained particles to an instantaneous continuous reduction in pressure whereby the comminuting operation is accomplished by explosion of the larger particles in a relatively low pressure atmosphere.

It is still another object of the present invention to drive an entraining stream of fluid with particles of a permeable material therein, through a restricted orifice thereby subjecting the entrained permeated particles to a drop in environment pressure which results in an explosion of these particles into a highly pulverized state.

In accordance with the general features of the present invention, there is provided herein a comminuting system for a permeable material such as coal or the like including a relatively low pressure source of entraining gas such as steam, means for superheating the steam, a source of permeable material which has been pretreated to render the particles thereof of such a size that they may flow with relative ease, means for entraining the particles in said superheated steam and a restricted passage or orifice which may take the form of a convergent-divergent nozzle through which the relatively low pressure stream and the entrained particles may pass at a high velocity, or may take the form of a sharp edged or rounded orifice, the particles exploding in the relatively rarefied environment at the outlet side of the orifice or the divergent portion of the nozzle. There may be also provided herein, at the outlet of said nozzle, a vortex separator into which the entrained, comminuted particles and the steam are passed tangentially, the steam passing upwardly of the separator while the particles pass downwardly therein to be subjected to a desired reaction or to be received in a suitable receptacle. If desired the separated steam may then be subjected to a reduced pressure whereby the pressure ratio at the discharge of the orifice or nozzle is further increased to further increase the velocity of the entrained particles to be comminuted therethrough and to thus further increase the speed efficacy of the comminuting action.

It is another object of the invention to provide an improved method of flash pulverization of a permeable material which includes the steps of entraining and permeating the material with a stream of low pressure, low velocity, fluid, treating the fluid and the entrained stream to eliminate excess moisture therefrom, controlling the flow of the entrained stream to direct the same into a rarefied atmosphere thereby to subject the entrained particles to a rapid instantaneous reduction in pressure to explode the same, rapidly separating the material thus pulverized from the entraining stream, subjecting the separated, pulverized material to a desired reaction such as a water gas reaction and, if desired, reducing the pressure of the separated gas to further increase the pressure ratio to enhance and augment the exploding action and the velocity of travel of the particles to be pulverized.

It is still another object of the invention to provide an improved method of flash pulverization which includes the steps of entraining and permeating the material with a stream of fluid and directing the entraining stream through a restricted orifice to subject the entrained particles to a high ratio of expansion to explode the same.

Many other objects and advantages of the invention will become apparent from the following description and accompanying drawing in which:

Fig. 1 is a cross sectional view of an improved apparatus by means of which the above objects may be attained;

Fig. 2 is an enlarged cross sectional view of the cyclone separator taken on the line II—II of Fig. 1; and

Fig. 3 is a side elevation of the connection between the cyclone separator and the receptacle.

It will be understood that the embodiment enclosed herein is illustrative of the invention and may be changed or modified without departing from the spirit and scope of the invention as set forth in the appended claims.

As shown in Fig. 1, the improved apparatus consists generally of a source 10 of steam or other gas, a source 11 of coal or other material to be comminuted and an outlet 12 for the comminuted material and entraining fluid, steam or other gas.

The source 10 for the fluid or steam comprises a pressure conduit 13 having a valve 14 therein. It will be seen that the valve 14 comprises the main control of the system and when shut down com-

pletely closes off the source of entraining gas. For purposes of description herein, steam will be referred to as the entraining and permeating medium. The steam conduit 13 connects with a transverse conduit 15 having a condensate discharge tube 16 provided with a valve 17, and also having a pressure gauge 16a therein. To the end that the steam may be superheated and thus completely dried, any suitable heating means such as a bank of burners 18 having a gas supply 19 may be provided.

The source 11 for the material comprises an inlet in the upper end of a hopper 20 which is provided with an outlet tube 21. To the end that positive feed of the material to be pulverized may be obtained, this outlet tube 21 of the hopper 20 is provided with a transverse section 22 into which is fitted rotatably a screw 23. The screw 23 is provided at one end with a spindle 24 which is rotatably mounted in a suitable bushing 26. The spindle 25 is in turn coupled as at 27 with the drive shaft 28 of a suitable electric motor 29. Thus it will be seen that as the granulated material from the hopper 20 descends into the tube 21 it is picked up by the screw 23 and positively forced into a lower section 30 of the tube. This section 30 of the hopper outlet tube leads into the upper side of the transverse steam conduit 15, the latter having a dead end extension 31. This dead end section 31, if desired, may be provided with a pressure gage 32 by means of which the pressure in the system may be determined. Preferably the tube 15 is provided with a regulating valve 33 whereby the section 15 of the steam conduit may be entirely closed.

To the end that a condition of pressure equilibrium may be established in the hopper 20 there is provided herein an auxiliary steam conduit 34 which connects the upper end of the hopper 20 with the steam conduit 15. Preferably this conduit 34 is provided with a shut-off valve 35 which may be regulated in conjunction with the valve 33 to provide the desired flow condition and whereby, if desired, the entire source of entraining steam may be bypassed through the top of the hopper 20 and downwardly to carry the material to be pulverized downwardly through the section 30 of the hopper outlet tube. This condition of course is created by entirely closing the valve 33 and opening the valve 35.

The material to be pulverized which passes downwardly in the tube section 30 is fed directly into the depending conduit 36 the details of which will be explained more fully presently.

To the end that moisture may be entirely eliminated from the final pulverized product, and in order to drive off volatile components if that procedure is desirable, the hopper 20 is preferably provided with a spaced jacket 37 which is closed around the upper end of the hopper 20 as at 38 and which extends downwardly and around the upper end of outlet tube section 21. The jacket 37 is further provided with outlets 39 at the lower end thereof which allow heating gases to escape as will presently be seen.

Suitably mounted near the upper end of the chamber formed between the hopper 20 and the jacket 37 is a ring burner 40 having a source of gas 41. It will be seen that when the ring burner 40 is ignited the chamber between the hopper 20 and the jacket 37 will attain an elevated temperature whereby the contents of the hopper are thoroughly heated and dried to prevent the formation of a slurry as the final product of the present method and apparatus or to drive off volatile components which may be collected and used as desired to provide a coking process if this is necessary. The products of combustion utilized in heating the hopper 20 escape through ports 39 in the jacket 37 and may escape to the atmosphere as shown or may be recirculated in the chamber in any suitable manner.

From the foregoing it will be seen that there is provided herein an apparatus whereby particles of a material to be pulverized may first be entrained in the stream of fluid, super heated steam or other gas whereupon they are delivered to a pulverizing system to be described presently, the inlet of which comprises the conduit 36 depending from the transverse steam conduit 15.

If desired the inlet 11 for the material to be pulverized may be provided with a valve 11a or any other suitable lock valve whereby the material is positively fed to the hopper 20 and yet whereby the entrance thereof into the hopper will not be detrimentally effected by the pressures developed in the system.

As indicated above, the material to be pulverized, after it has passed the screw feed 23, flows into the conduit 15 where it is further entrained in the superheated steam and then driven into the conduit 36. Thus it will be seen that the permeable material, by means of the above described method and apparatus, has been preliminarily treated in such a manner that it is thoroughly permeated with the entraining gas preparatory to the pulverizing operation now to be described.

Interposed in the outlet of the steam conduit 15 and beyond the section 36 of the outlet thereof is a convergent-divergent nozzle 42. As indicated previously, any suitable restricted orifice may be utilized instead of the nozzle 42 so long as the desired pressure ratio is obtained by passage of the entrained permeated particles therethrough. As the gas permeated material is driven beyond the conduit section 36 it is contemplated that the velocity thereof is on the order of ten to one hundred feet per second while the velocity attained by the particles at the throat and in the divergent portion of the nozzle is on the order of two to four thousand feet per second. Thus it will be seen that not only is the passage through the nozzle practically instantaneous but furthermore there is developed an exceedingly large drop in pressure which results in an explosion of the particles and in a disintegration thereof to provide a highly comminuted final product.

From the foregoing it will be seen that the delivery and conditioning portion of the apparatus has provided a stream of gas or fluid into which the particles to be pulverized are entrained, these particles being thoroughly permeated by the gas or fluid. Furthermore the entraining stream and the particles have been superheated to drive moisture therefrom thereby to prevent the formation of a slurry as a final product, to drive off volatile components and to retain the surfaces of the comminuted particles in an active condition. Thereafter the particle-loaded stream is subjected to the comminuting nozzle 42 having the characteristics described above whereby the material is exploded to provide the desired final, comminuted mass.

As the comminuted mass passes beyond the nozzle 42 it may be delivered to a conduit section 43 which leads tangentially into a separator 44. This separator may be provided with an internal structure of any desired type and functions to deliver the gas component of the mass upwardly into a conduit 45 as indicated by the arrow A and the comminuted particles downwardly in a vortex to the outlet 46 as indicated by the arrow B. The outlet 46 is provided with diametrically opposed, outwardly extending pins 47 which cooperate with bayonet slots 48 (Fig. 3) in the neck 49 of a coal reservoir 50. This reservoir 50 is preferably heated by means of a burner arrangement 51 having a gas supply 52 whereby the particles are maintained free of moisture and the active condition of the surface is retained. With the foregoing construction it will be seen that the removal of the reservoir 50 from the separator is obtained easily by mere rotation and downward movement of the reservoir when it has been filled. It will be understood of course that a more continuous system may be provided in place of the intermittently filled reservoir 50. Furthermore the comminuted particles may be delivered directly from the restricted orifice into a receiving chamber where the particles may be subjected to further comminution by means of pulsating pressure conditions created by over expansion at the restricted orifice. Additionally, if desired, the particles and entraining stream may be subjected in said chamber, to a process whereby direct generation of a gas is obtained.

The gas outlet conduit 45 of the cyclone separator 44 is preferably yoked at its upper end to provide the conduit 53 having a shut-off valve 54 and a conduit 55 having a shut-off valve 56. The conduit 53 opens to the atmosphere when the valve 54 is opened and the valve 56 is closed thus permitting complete escape of the gas.

The conduit 55 is arranged to connect with apparatus of any suitable construction when the valve 54 is closed and the valve 56 is opened thereby to create a reduced pressure to increase the expansion ratio at the restricted orifice. In this manner the velocity of the particles passing through the nozzle 42 and the ratio of expansion of the nozzle are greatly augmented thereby to generally augment the desired result as previously described.

From the foregoing it will be seen that there is provided herein a method and apparatus whereby a permeable material is pre-conditioned to be entrained in a stream of gas which may have a relatively low pressure, whereby this entraining stream is superheated to prevent the formation of a slurry and whereby this pre-conditioned mass is fed in an improved manner to an improved pulverizing arrangement. It will also be seen that by the provision of this pre-conditioning apparatus and by the provision of the nozzle 42, the transition of the permeable material from relatively large size particles to highly comminuted condition is instantaneous insofar as it is accomplished in the period of time required for the passage of the entrained particles through the nozzle. It will also be seen that if the finely comminuted particles are then delivered directly to a separator, they may be instantaneously delivered to a final reservoir whereby the activated condition of the surfaces there-

of is not detrimentally affected by a lapse of time or by exposure to detrimental conditions.

Thus it will be seen that there is provided herein a relatively simple and cheap apparatus and method for effectively and instantaneously reducing the size of the particles without these particles being subjected to conditions detrimental to the active nature of the surfaces thereof.

It will be seen that another attribute of the invention resides in the small amount of energy utilized in the comminution of the particles. In this regard it has been found that only a slight amount of the heat content of the entraining, permeating fluid or gas has been used and thus the residual heat content is available for further use if desired.

In utilizing the above described apparatus it will be seen that the separator 44 is admirably adapted to be used as a reaction chamber since the spiral action of the particles insures a complete exposure of the active surfaces to the environment therein. Furthermore it will be seen that the passage of the finely comminuted particles from the nozzle 42 to the separator 44 is almost instantaneous and thus the surfaces of the particles are still highly active. In such use of the apparatus, the reservoir 50 will then receive the ultimate products resulting from the above described method including the steps of superheating the gas and the particles, entraining the particles in, and permeating them by the gas, instantaneously exploding the entrained and permeated particles, rapidly delivering the exploded, active particles to the separator and there subjecting the exploded comminuted particles to a suitable reaction.

If desired the comminuted particles may be subjected to a desired reaction at the outlet of the restricted orifice (in the present embodiment, at the divergent portion of the nozzle 42) to ensure an activated condition of the surfaces during this reaction.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. An apparatus for comminuting or disintegrating a permeable material, including means for entraining in and permeating with a fluid stream, a mass of flowable particles of such material, and means for subjecting said stream and the entrained particles to a high ratio of expansion during flow thereof through the apparatus to explode said particles and to comminute the same.

2. An apparatus for comminuting or disintegrating a friable material, including means for entraining said material in a stream of fluid, means for comminuting said entrained material by subjecting the same to a reduction in pressure, and a reaction chamber for receiving said comminuted material before the surfaces have become inactivated by exposure.

3. An apparatus for comminuting or disintegrating a friable or permeable material, including means for entraining the material in a stream of fluid, and means for instantaneously increasing the velocity of flow of the entrained stream and for instantaneously subjecting the stream to reduced pressure conditions to comminute the material therein.

4. An apparatus according to claim 1, 2 or 3, having a conduit for conducting the fluid stream therethrough, means for feeding said permeable or friable material into said stream, and a conduit for the entrained stream of fluid and permeable material, said last named conduit having the means for subjecting said stream to reduced pressure conditions to comminute said material therein.

5. An apparatus according to claim 4, having a restricted orifice in said last named conduit for continuously receiving said entrained stream and subjecting said material to reduced pressure conditions during flow of the mixture thereby to comminute the same.

6. An apparatus according to any of the preceding claims, having means for heating the permeable or friable material before it is entrained into said fluid stream.

7. An apparatus according to claim 4, wherein the stream of fluid is conducted under pressure through the first conduit, a conduit is provided for conducting the flowable, permeable material into said first conduit from a source of said material, and a bypass conduit leads from said first conduit into said source of material for equalizing the fluid pressure therein.

8. An apparatus according to any of the preceding claims, comprising a reservoir for material to be comminuted or disintegrated and a receiving chamber for comminuted or disintegrated material, a conduit of generally uniform cross section connected with said reservoir and said receiving member, a source of fluid pressure connected with said conduit to afford flow of a fluid therethrough, and means in said conduit for comminuting or disintegrating said material as it flows therethrough at a high velocity, said

means consisting of a constricted portion in said conduit intermediate the connection thereof with said reservoir and said receiving member.

9. An apparatus according to claim 8, wherein said conduit has a first, up-stream portion for conveying material to be comminuted or disintegrated and a second, down-stream portion for conveying comminuted or disintegrated material, said conduit portions having therebetween the constricted portion constructed to impart a high ratio of explosive expansion to material flowed therethrough.

10. An apparatus according to any of the preceding claims, having means for superheating the stream of fluid.

11. A method of comminuting a permeable or friable material, which includes the steps of entraining in and permeating with a continuously flowing fluid, particles of said permeable material and subjecting the entrained material to an instantaneous reduction in environmental pressure to comminute the same.

12. A method according to claim 11, in which the entrained particles, with the entraining stream, is passed through a restricted passage or orifice to subject the same to an instantaneous reduction in pressure thereby to comminute the same and expose active surfaces thereof.

13. A method according to claim 11 or 12, in which the fluid is separated from the comminuted particles and the pressure of the separated fluid is reduced to augment the comminuting instantaneous pressure reduction.

14. A method according to claim 11, in which the stream of fluid and the mass of particles of the material are superheated before being subjected to the reduction in pressure.

15. A method according to any of the claims 11 to 14, in which the comminuted material is subsequently delivered to a reaction chamber before the surfaces thereof become inactivated by exposure.

16. A continuous flow apparatus for comminuting a permeable material, constructed substantially as herein described with reference to the accompanying drawings.

17. A method of comminuting a permeable or friable material, substantially as herein described with reference to the accompanying drawings.

Dated this 30th day of April, 1945.
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[This Drawing is a reproduction of the Original on a reduced scale.]

FIG. 1

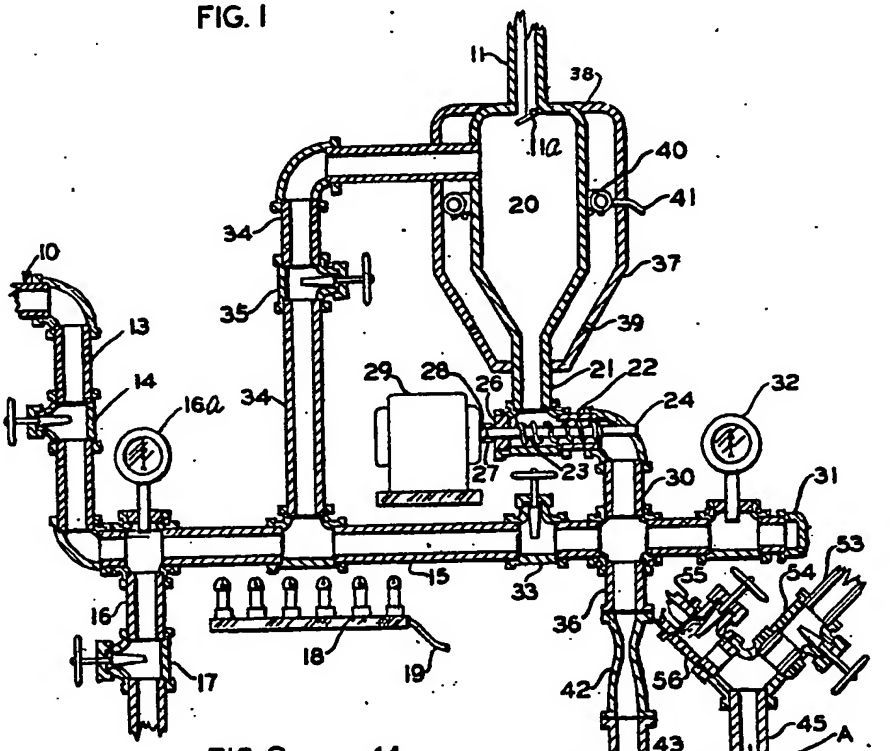

FIG. 2

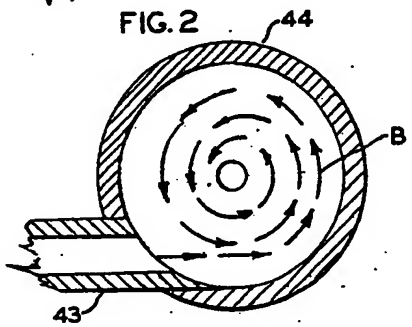

FIG. 3